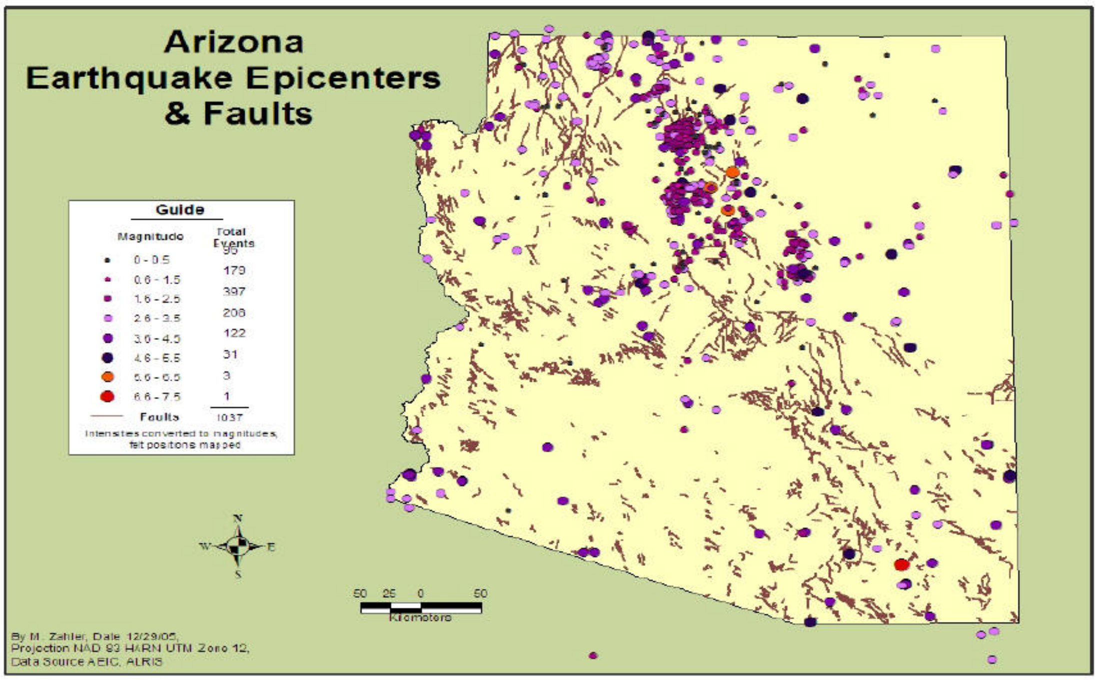
5.4.3 Earthquake

History

Contrary to general thinking, Arizona lies within and adjacent to seismic zones that have the potential to damage major structures such as dams and roadways, and the potential to cause loss of life. Earthquakes have been described as shaking, ground-rolling vibrations caused by strain release along faults. Active faults are known to exist in northern Arizona and California and Mexico have generated large earthquakes that have damaged structures within Arizona's borders. For Arizona, existing studies (Scarborough and others, 1983; Menges and Pearthree, 1983; Pearthree and others, 1983; and Scarborough and others, 1986) define active faults as those that exhibit signs of surface displacement, or movement within about the last 4 million years (Late Pliocene-Quaternary). With a growing population, earthquake risks in Arizona are growing too.



Earthquakes generated within Arizona are largely centered in the north-central portion of the State. The earthquake's size is depicted with a relative sized color-coded circle. The two largest earthquakes to have been estimated and recorded occurred in southern Arizona (San Pedro Earthquake) and north of Flagstaff. Several faults (depicted as brown lineaments) have been identified within Arizona, some of which are known to generate earthquakes. This figure has been modified from AZ Earthquake Information Center, AZ Earthquake & Fault Maps web page, www4.nau.edu/geology/aeic/EQ_Fault_maps.html.

Several hundred earthquakes have occurred in Arizona over the last 150 years (DuBois et al., 1982), some of which have been estimated and recorded at magnitude 4.9 or greater, see below. Heavy damage resulted from at least 3 earthquakes (1852, 1887, and 1940), moderate effects have been reported for at least 40 events, and minor effects are consistently reported throughout historic times and number in the several hundreds (DuBois, et al., 1982). There have been 14 tremors of intensity V to VII centered within Arizona's borders (USGS, Sept. 12, 2003). A total of 10 major earthquakes were recorded during the 1800s and another 32 recorded during the 1900s. Numerous smaller earthquakes, however, have been recorded throughout the 1900s (Bausch & Brumbaugh, May 23, 1994).

No.	Date	Magnitude/ Intensity	Location	No.	Date	Magnitude/ Intensity	Location
1	1830	IX	San Pedro	16	17-Jun-1922	VI	Miami
2	2 May 1872	VI	Yuma	17	28-Jul-1931	VI	Cottonwood
3	3 Nov 1875	VI	Yuma	18	1-Jan-1935	VI	Grand Canyon
4	11 Nov 1887	VII	Pantano	19	2-Jan-1935	VI	Welton
5	25 Jul 1888	VI	Tombstone	20	10-Jan-1935	VI	Grand Canyon
6	19-Aug	VI	Yuma	21	8-Apr-1937	VI	Ganado
7	13-Nov	VI	Yuma	22	29-Sep-1938	VI	Clifton
8	10 Jun 1890	VI	Yuma	23	9-Mar-1939	VI	Grand Canyon
9	2 Feb 1892	VI	Flagstaff	24	4-Jun-1939	VI	Duncan
10	25-Jan-1906	6.2	Flagstaff	25	16-Jan-1950	VII	Ganado
11	24-Sep-1910	6.0	Cedar Wash	26	21-Jul-1959	5.5	Fredonia
12	18-Aug-1912	6.2	Lockett Tanks	27	13-Oct-1959	5.0	Flagstaff
13	30-Mar-1916	VI	Nogales	28	4-Feb-1976	4.9	Chino Valley
14	12-Dec-1916	VI	St Michaels	29	25-Apr-1993	4.9	Cataract Creek
15	6-Apr-1921	VI	Holbrook	30	29-Apr-1993	5.4	Cataract Creek

AZ earthquakes recorded or estimated at magnitude 4.9 or greater (Modified from AZ Earthquake Information Center, AZ Earthquakes 1830-2006 web page, www4.nau.edu/geology/aeic/EQhistory.html#P using DuBois et al., 1982).

The Arizona Geological Survey (AZGS) has prepared a map displaying the intensity of historical earthquakes that have affected Arizona using the MMI scale. The southeastern and southwestern corners of the State have been subject to the greatest intensity earthquakes. The earthquakes affecting the southeastern corner appear to originate in Mexico. Most of the earthquakes felt in Yuma have originated in southern California and northern Mexico. A zone of lesser ground shaking intensity extends from around Flagstaff northward. Within Arizona, earthquakes have most commonly occurred between Flagstaff and the Grand Canyon. The following are examples of major earthquakes that have affected and/or occurred within Arizona:

Southern Arizona

The earliest recorded earthquake affecting Arizona, and possibly the largest, occurred in 1830. With an estimated intensity of IX recorded at San Pedro, approximately 25 miles west of Tucson, the earthquake would have caused massive damage to built structures (ADEM, March 1998).

1887, the Sonoran earthquake caused significant destruction in southern Arizona towns, including Tucson, and was one of the largest earthquakes in North American history. The earthquake was caused by the reactivation of a basin and range normal fault that is similar to other faults in Arizona (DuBois & Smith, 1980). The epicenter was located approximately 100 miles south of Douglas, Arizona, along the Pitaycachi fault in Mexico, and caused great destruction at its epicenter. The earthquake was so large that it was felt from Guaymas, Mexico to Albuquerque, New Mexico. It is estimated variously to have been an intensity VII and magnitude 7.2 earthquake. In Arizona, water in tanks spilled over, buildings cracked, chimneys toppled, and railroad cars were set in motion. An observer at Tombstone, near the Mexican border, reported sounds ``like prolonged artillery fire'' (ADEM, March 1998; Bausch & Brumbaugh, May 23, 1994; USGS, Sept. 12, 2003; Univ of AZ). With the increase in development, if such an earthquake occurred today it would cause extensive damage in southeastern Arizona (Jenny & Reynolds, 1989).

Southwestern Arizona

The earliest descriptions of earthquakes in Arizona occurred in the 1800s on the California side of the Colorado River and are recorded at Fort Yuma. Shocks that probably centered in the Imperial Valley of California or in Mexico have been noted in Fort Yuma since late 1852. Yuma has experienced repeated damage from California earthquakes, such as the M 7.1 on May 18, 1940, the M 6.5 on October 15, 1979 & the M 6.4 on Dec. 19, 1979 (ADEM, March 1998; Bausch & Brumbaugh, May 23, 1994).

January 2, 1935, an earthquake cracked walls and plaster at Wellton, located a few miles east of Yuma. While few residents of the small town were frightened by the tremor, everyone felt the ground quivering and homes shaking (USGS, Sept. 12, 2003).

Northern Arizona

1906, the first earthquake with recorded magnitude occurred in Flagstaff, registering M 6.2. However, Northern Arizona experienced a rash of earthquakes in the early part of this century. (ADEM, March 1998; University of Arizona).

September 10-23, 1910, a series of 52 earthquakes caused a construction crew in the Coconino Forest near Flagstaff to break camp and leave the area as boulders rolled down on the camp from nearby mountains. The shocks grew in intensity over the two-week period until September 23, when a very strong shock was felt throughout northern Arizona. The earthquake was so severe north of the San Francisco Mountains that people fled from the region (USGS, Sept. 12, 2003).

August 8, 1912, an earthquake caused a 50-mile-long crack in the earth north of the San Francisco Range, damaging houses at Williams. The shock was strongest in Coconino County, north of Flagstaff, where rockslides roared down the mountainsides, and the earth seemed to roll ``like waves on the Colorado River'' (USGS, Sept. 12, 2003).

January 10, 1935, a slightly stronger earthquake awakened sleepers at Grand Canyon. The distinct subterranean rumble and the movement of houses frightened many. Walls were cracked in some cases, and rockslides occurred in the mountains. Grand Canyon residents felt three slight foreshocks during the first week of January, and one very minor aftershock was noted on January 15 (USGS, Sept. 12, 2003).

Eastern Arizona

January 16, 1950, a strong earthquake (intensity VII) rocked Apache County leaving several cracks in the ground as it rumbled through the small town of Ganado. The cracks, one-half inch wide and up to 12 feet long, extended in a north-south direction near the Ganado Trading Post (USGS, Sept. 12, 2003).

Earthquake energy, also referred to as seismic activity is commonly described in terms of magnitude and intensity. Magnitude (M) describes the total energy released and intensity (I) subjectively describes the effects at a particular location. Although an earthquake has only one magnitude, its intensity varies by distance from the epicenter, surface materials (e.g., soil, bedrock), and building types. Magnitude is the measure of the amplitude (height) of the seismic wave and is expressed by the Richter scale. The Richter scale is a logarithmic measurement, where an increase in the scale by one whole number represents a tenfold increase in measured amplitude of the seismic waves (and 32 times more energy). Intensity is a measure of how strong the shock was felt at a particular location, and is expressed by the Modified Mercalli Intensity (MMI) scale.

Another way of expressing an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. The acceleration due to gravity is often called "g" and is equal to 9.8 meters per second squared (9.80 m/sec^2). This means that every second something falls towards earth, its velocity increases by 9.8 meters per second. Peak ground acceleration (PGA) measures the rate of change of motion relative to the rate of acceleration due to gravity. For example, acceleration of the ground surface of 2.44 m/sec^2 equals a PGA of 25%.

Earthquake PGA, Magnitude and Intensity Comparison

PGA (%g)	Magnitude (Richter)	Intensity (MMI)	Description (MMI)
<0.17	1.0 - 3.0	I	I. Not felt except by a very few under especially favorable conditions.
0.17 - 1.4	3.0 - 3.9	II - III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
1.4 - 9.2	4.0 - 4.9	IV - V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motorcars rock noticeably. V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
9.2 - 34	5.0 - 5.9	VI - VII	VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
34 - 124	6.0 - 6.9	VII - IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
>124	7.0 and higher	X or higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed, rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: Wald, Quitoriano, Heaton, and Kanamori, 1999.

It is possible to approximate the relationship between PGA, the magnitude and the intensity, as shown above. The relationships are, approximate, and depend upon such specifics as the distance from the epicenter, depth of the epicenter, and type of surficial material. An earthquake with 10% PGA would roughly correspond to an intensity of V or VI, described as being felt by everyone, overturning unstable objects, or moving heavy furniture.

Secondary Hazards from Earthquakes

One of the secondary hazards from earthquakes is surface rupture, the differential movement of two sides of a fault at the earth's surface. Linear structures such as railways, highways, pipelines, and tunnels built across active surface faults, are extremely susceptible to being damaged by earthquakes. Displacement along faults, both in terms of length and width, varies but can be significant (e.g., up to 20 feet), as can the length of the surface rupture (e.g., up to 200 miles).

Earthquake-related ground failure, due to liquefaction and potential landslides and rock falls, are known to cause significant damage in areas affected by earthquakes. Liquefaction occurs when seismic waves pass through saturated granular soil, distorting its granular structure, and causing some of the empty spaces between granules to collapse. Liquefaction has occurred in southern Arizona due to the San Bernardino Valley 1887 earthquake and western Arizona due to several California earthquakes (DuBois & Smith, 1980; DuBois et al., 1982). Pore-water pressure may also increase sufficiently to cause the soil to behave like a fluid (rather than a soil) for a brief period and cause deformations. Liquefaction causes lateral spreads (horizontal movement commonly 10-15 feet, but up to 100 feet), flow failures (massive flows of soil, typically hundreds of feet, but up to 12 miles), and loss of bearing strength (soil deformations causing structures to settle or tip). Earthquake induced landslides and rock falls often result in a considerable portion of the damage associated with historical earthquakes. Falls of precarious rocks may be triggered by small earthquakes in steep terrain. Slopes in their natural condition are generally far less susceptible to instability than those that are altered by activities of man.

Map 20

Updated map with original data – Earthquake intensity or strength is measured using the Modified Mercalli Intensity Scale.

Map 21

Updated map with original data – Peak Acceleration is explained by the USGS as related to: building codes prescribe how much horizontal force buildings should be able to withstand during an earthquake. This force is related to the ground acceleration. The peak acceleration is the maximum acceleration experienced by the particle during the course of the earthquake motion.

Probability and Magnitude

Probabilistic ground motion maps are typically used to assess the magnitude and frequency of seismic events. These maps measure the probability of exceeding a certain ground motion, expressed as peak ground acceleration (PGA), over a specified period of years. For example, the following map displays the probability of exceeding a certain ground motion, expressed as PGA, in 50 years in the Western United States. This is a common earthquake measurement that shows three things: the geographic area affected (colored areas on map below); the probability of an earthquake of each level of severity (e.g., 10% chance in 50 years); and the severity (PGA) as indicated by color.

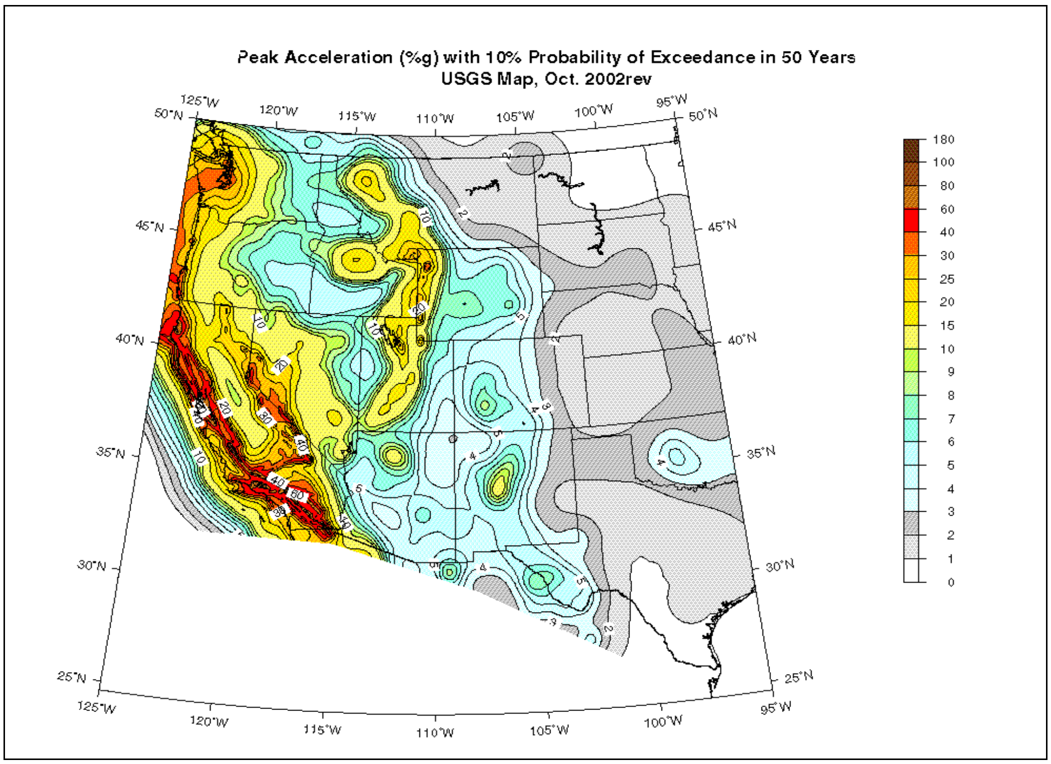
Note that this map expresses a 10% probability of exceedance and, therefore, there is a 90% chance that the peak ground acceleration displayed will not be exceeded during 50 years. The use of a 50-year period to characterize the percent chance of exceedance is arbitrary and does not imply the structures are thought to have a useful live of only 50 years. Similar maps exist for other measures of acceleration, probabilities, and time periods. It is useful to note that, according to the USGS, a PGA of approximately 10% gravity (10 pg) is the approximate threshold of damage to older (pre-1965) dwellings or dwellings not made resistant to earthquakes. The 10 pg measure was chosen because, on average, it corresponds to the MMI VI to VII levels of threshold damage in California within 25 km of an earthquake epicenter. The earthquake hazard maps combine near and distant ground motions indiscriminately and should not be used for particular buildings (USGS, Feb. 7, 2003).

Most of Arizona has a PGA of about 4.0 to 5.0 pg, with only the north-central and far southwestern parts of the state having a PGA of 10 pg or more. While these values are low in comparison with many parts of California, the National Earthquakes Hazard Reduction Program (NEHRP) a federally established interagency program has designated Arizona a "high risk" state for earthquakes (Bausch & Brumbaugh, May 23, 1996).

Yuma County, particularly the City of Yuma and nearby communities, face the highest risk from earthquakes in Arizona. Large portions of Yuma County have a PGA of 10% or higher. Furthermore, the southwestern corner of Yuma County has a PGA of 20%, which is the greatest in the state. Earthquakes originating in southern California and northern Mexico cause ground shaking in Yuma on an annual basis.

Four major faults lie outside the state within 65 miles of Yuma: Imperial (28 miles), Cerro Prieto (45 miles), San Andreas (65 miles), and San Jacinto (65 miles). The stretch of the San Andreas Fault nearest Yuma has not ruptured in over 300 years and is considered a likely area to experience an earthquake of M 8.0 or higher (which would cause catastrophic damage in the area). Compounding the earthquake risk is the fact that large parts of the Yuma area will also be subject to liquefaction in the event of a major earthquake (Bausch & Brumbaugh, May 23, 1996).

The seismic hazard in Coconino County, particularly the area north of Flagstaff, is considered second only to that of the Yuma area. This area, which is also known as the Northern Arizona Seismic Belt (NASB), has a PGA of 15 pg and was the source of a number of large (M 6.0 or higher) earthquakes in the early 1900s and numerous smaller earthquakes since then. These events indicate that there is a 50% chance of an M 6.0 or higher earthquake during the next 30 years in the NASB (which would cause significant damage in the area). This event is considered to be the maximum probable earthquake for the Flagstaff area (Bausch & Brumbaugh, May 7, 1997).



Western United States Peak Ground Acceleration Map Source: United States Geological Survey, April 2003

A significant portion of Mohave County has a PGA of 15 pg. The Hurricane Fault in northern Mohave County has the fastest displacement rate, longest length, and largest maximum credible earthquake (M 7.75) of any Arizona fault. Historic earthquakes in the area include the following: M 5.0 Hoover Dam earthquake on May 4, 1939; M 6.4 Afton (California) earthquake on April 10, 1947; and the M 5.5-5.75 Fredonia earthquake on July 21, 1959. These quakes were felt over wide areas and caused numerous large rock falls and landslides. Earthquake risk factors for Mohave County include three large dams (Hoover, Parker, and Davis), growing population, and a high proportion of unreinforced masonry buildings (Bausch & Brumbaugh, July 30, 1997).

Portions of La Paz County are located within 100 miles of the San Andreas Fault system, resulting in a PGA of 10 pg. Historically, La Paz County has experienced strong earthquakes from California, including the M 7.1 Imperial Valley earthquake in May 1940, as well as smaller earthquakes from within La Paz county itself. Portions of the county also meet the criteria for liquefaction to occur (Bausch & Brumbaugh, Aug. 31, 1997).

Parts of Yavapai County have a PGA of 9 pg. The county is subject to significant ground shaking from earthquakes originating on faults within the county and from nearby sources, such as the Hurricane and Toroweap faults and the NASB. The county is also underlain by a series of faults that bisect it from northwest to southeast, and that have a potential for a M 7.25 earthquake (Bausch & Brumbaugh, June 28, 1997).

The seismic risk in the developed portions of Maricopa County is generally low, with PGA zones of 4-5 pg in most of metropolitan Phoenix. The southwestern corner of the county has elevated seismic risk where the PGA increases to15 pg, although this region is largely uninhabited. The seismic risk to the Phoenix area is elevated, however, due to the large and rapidly expanding population, existence of high rise buildings, predominance of un-reinforced masonry buildings, and lack of earthquake awareness among its population (Bausch & Brumbaugh, June 13, 1994).

The rate of seismicity in the Phoenix area is low, with the most recent quakes originating in Cave Creek in 1974 (M 2.5 and M 3.0) and the Mogollon Plateau near Payson in 2003 (4.6). However, the area has been impacted by major earthquakes in southern California and northern Mexico, including the 1887 Sonoran earthquake (M 7.2), which caused ground shaking and triggered rock falls in the Phoenix area. The largest impact of an earthquake on the Phoenix metropolitan area would be the economic impact from a catastrophic southern California earthquake, which would disrupt approximately 60% of Arizona's fuel and 90% of Arizona's food goods. The Phoenix area could also be significantly affected by a major earthquake in Yuma or the NASB.

A repeat of the 1887 earthquake would result in significant damage to Arizona's population centers, particularly where development is located on alluvial plains and steep slopes, which is the case in much of the Phoenix area. The Sugarloaf and Horseshoe faults are the nearest mapped potentially active faults, both approximately 40 miles northeast of the Phoenix area. A M 6.75 event is the largest credible earthquake that could occur on these faults, which would result in rock falls, dam failure, liquefaction, destructive resonance in reinforced concrete buildings three to four stories in height, and ground motion sufficient to cause damage in other structures (Bausch & Brumbaugh, June 13, 1994).

It should also be noted that although the small earthquakes that commonly occur in Arizona pose low seismic risk to buildings, the repeated shaking could eventually cause structural damage. Small earthquakes may also trigger landslides in unstable areas and cause boulders to roll off mountain slopes (Jenny & Reynolds, 1989).

In an attempt to categorize the probability of future earthquake events, the hazard was analyzed using the CPRI. This method also takes into account the levels of magnitude/severity, warning time and duration. In Arizona, earthquakes are possible, the magnitude/severity is typically negligible, the warning time is less than 6 hours and the duration is always less than 6 hours as well. These factors resulted in a CPRI rating of 1.9. The highest rating a hazard can result in using this method is 4.

Vulnerability

The impact or losses from earthquakes has generally been low in the more developed and populated areas of the State. Small earthquakes with low seismic risk to buildings have occurred, which with repeated shaking can cause structural damage (URS, AZ original Plan, 2004). Also, if an earthquake impacts an area of sensitivity or initiates a secondary hazard such as dam failure, subsidence or fissures, the damages and loss of life could be substantial.

For the local risk assessment summary, the table below combines asset and predominantly HAZUS information for the estimated losses as reflected in local plans. The potential total number of facilities in earthquake areas is 1,275,149 at a replacement cost of $236 billion. The estimated losses for an earthquake are approximately $4.7 billion.

Summary of Local Risk Assessment & loss estimates based on Earthquake			
	Total Assets $ (Assets +HAZUS) x $1,000	# of Facilities Impacted (Assets + HAZUS)	Estimated Loss
Statewide Totals	$236,046,152	1,275,149	$4,707,168,000
Maricopa	$188,380,403	994,383	$6,438,000
Mohave	-----	-----	$730,000
Pima	$47,665,749	280,766	$3,200,000,000
Yuma	-----	-----	$1,500,000,000
----- Denotes lack of available information for assessment.			

Sources:

Earthquake hazards in Arizona: P.A. Pearthree and D.B. Bausch, 1999, AZGS Map 34, text and map, scale 1:1,000,000.

Quaternary fault data and map for Arizona: P.A. Pearthree, compiler, 1998, AZGS OpenFile Report 9824, 122 p., scale 1:750,000, 1 disk.

PlioQuaternary faulting and seismic hazard in the Flagstaff area, northern Arizona: P.A. Pearthree and others, 1996, AZGS Bulletin 200, 40 p., 2 sheets, scale 1:50,000 and 1:100,000.

Seismic hazards in Arizona: D.B. Bausch and D.S. Brumbaugh, 1994, Flagstaff, AZ Earthquake Information Center, 49 p., 2 sheets, scale 1:1,000,000.

Arizona earthquakes: S.M. DuBois and others, 1982, AZGS Bulletin 193, 456 p., scale 1:1,000,000.

The 1887 earthquake in San Bernardino Valley, Sonora: Historic accounts & intensity patterns in AZ: DuBois/A.W. Smith, 1980, AZGS Special Paper 3, 112 p.

Arizona State University, May 26, 2003."Earthquake information for the State of Arizona & the world." http://activetectonics.la.asu.edu/e-quakes/

Bausch, Douglas B. and David S. Brumbaugh:

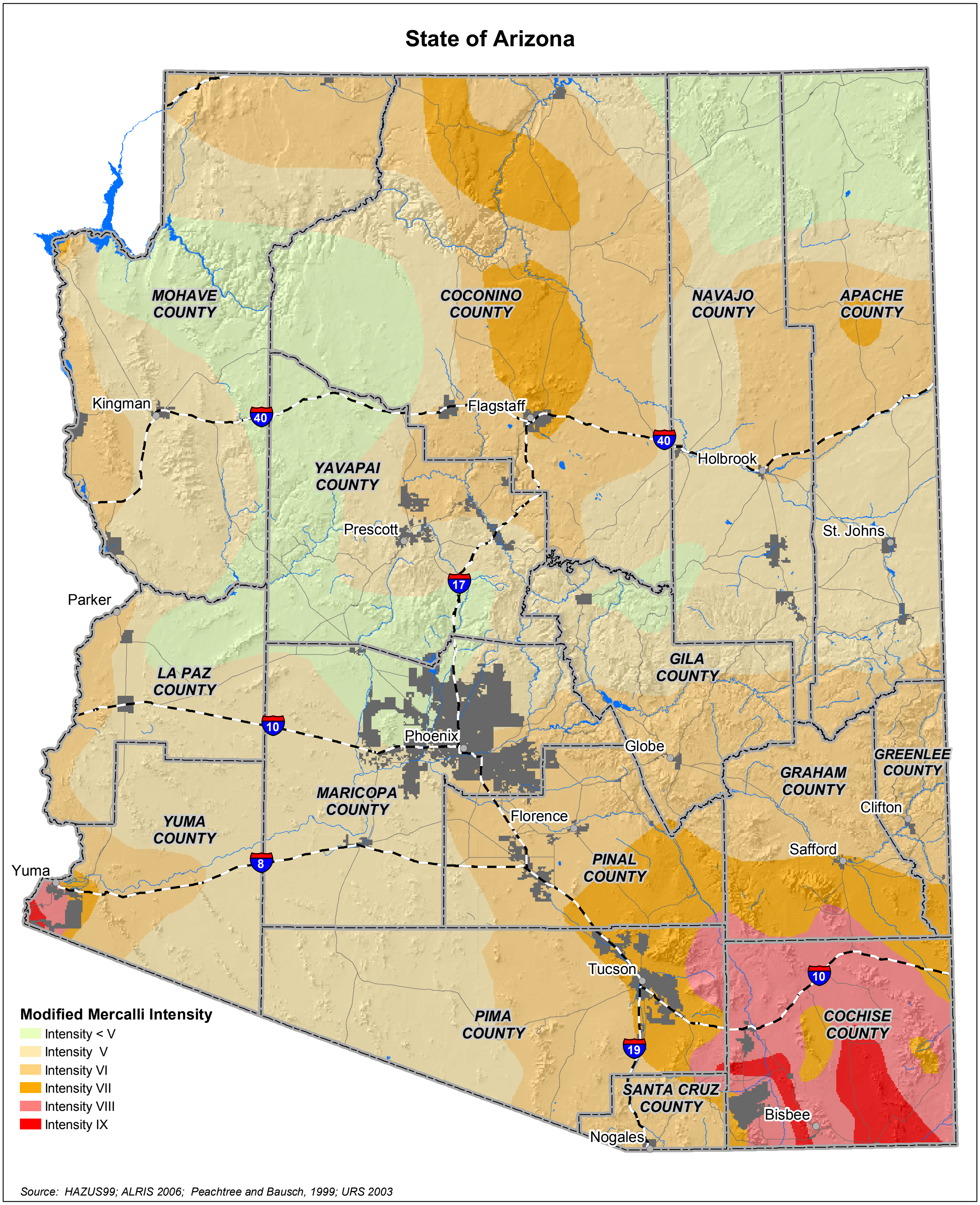
- May 23, 1994. Seismic Hazards in Arizona –Arizona Ground Shaking Intensity & 100 yr Acceleration Contour Maps.http://www4.nau.edu/geology/aeic/staterep.txt
- June 13, 1994. Phoenix Community Earthquake Hazard Evaluation, Maricopa County, Arizona.http://www4.nau.edu/geology/aeic/phoehaz.txt
- May 23, 1996. Yuma County Earthquake Hazard Evaluation, Yuma County, Arizona.http://www4.nau.edu/geology/aeic/yumarep.html
- May 7, 1997. Flagstaff Community Earthquake Hazard Evaluation, Coconino County, Arizona.http://www4.nau.edu/geology/aeic/flag.html
- June 28, 1997. Earthquake Hazard Evaluation Yavapai County, Arizona.http://www4.nau.edu/geology/aeic/yavapai.html
- July 30, 1997. Earthquake Hazard Evaluation Mohave County, Arizona.http://www4.nau.edu/geology/aeic/mohave.html
- August 31, 1997. Earthquake Hazard Evaluation La Paz County, Arizona.http://www4.nau.edu/geology/aeic/lapaz.html

Jenny, J.P. and S.J. Reynolds, 1989. "Geologic Evolution of Arizona" in Arizona Geological Society Digest, No. 17.

US Geological Survey (USGS):

- February 7, 2003, "Definition of %g – What is the relation to Building Damage?" http://geohazards.cr.usgs.gov/eq/faq/parm02.html
- September 12, 2003, "Earthquake History of Arizona." http://wwwneic.cr.usgs.gov/neis/states/arizona/arizona_history.html

Wald, David J., Vincent Quitoriano, Thomas H. Heaton and Hiro Kanamori, 1999. "Relationship between Peak Ground Acceleration, Peak Ground Motion and Modified Mercalli Intensity in California" in Earthquake Spectra, Vol. 15, No. 3, 557-564. http://pasadena.wr.usgs.gov/shake/pubs/regress/regress.html



Legend

Major City	County
interstate	Lakes
Highway	Cities
Major Streams	

N

0 25 50
Miles

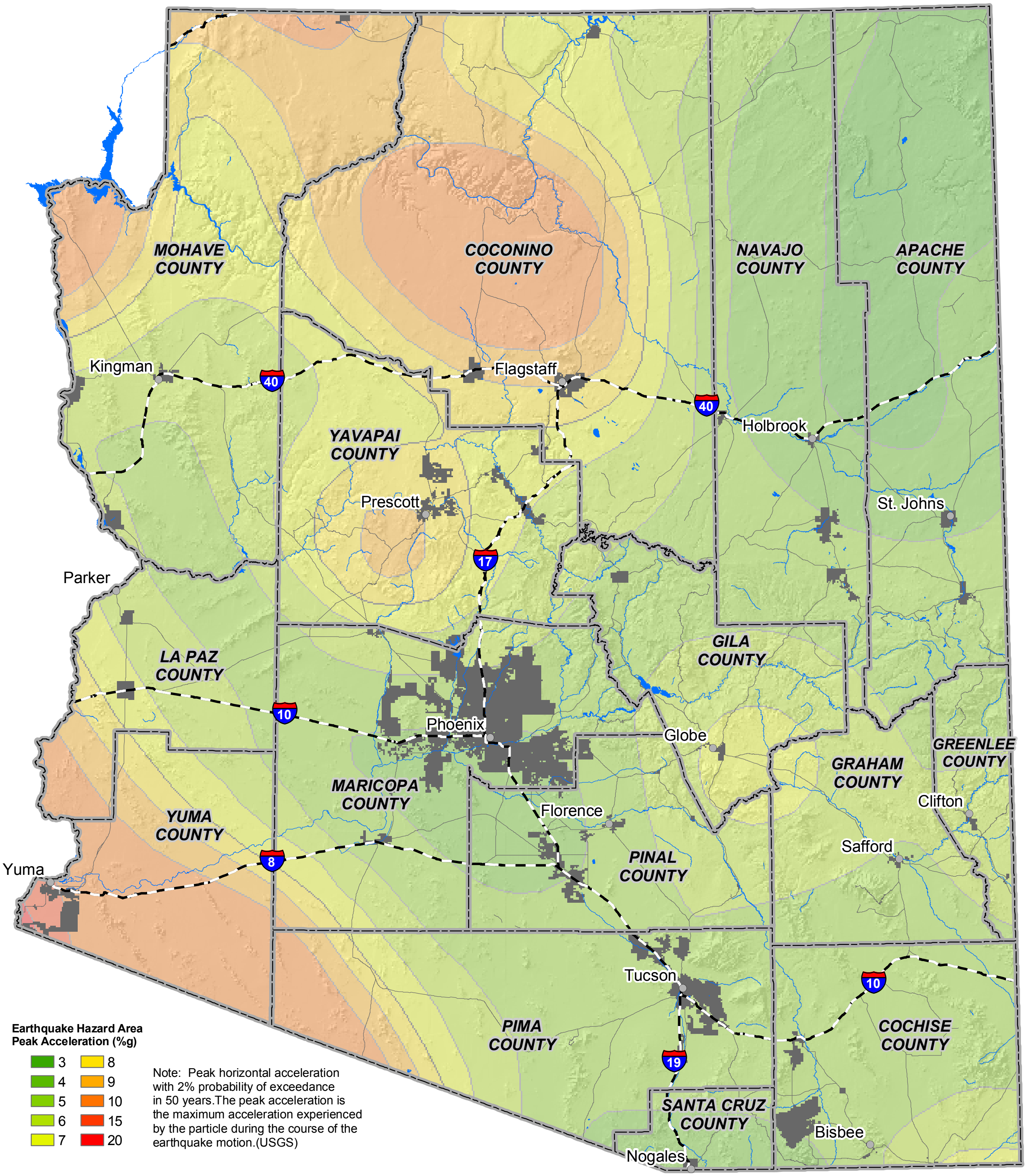
August 2007

State of Arizona Multi-Hazard Mitigation Plan

Map 20
Maximum Intensity Ground Shaking and Earthquake Damage
1975 thru Present

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

State of Arizona



Note: Peak horizontal acceleration with 2% probability of exceedance in 50 years.The peak acceleration is the maximum acceleration experienced by the particle during the course of the earthquake motion.(USGS)

Source: HAZUS99; ALRIS 2006; Peachtree and Bausch, 1999; Arizona Geological Survey, 1999; URS 2003

Legend

- Major City
- interstate
- Highway
- Major Streams
- County
- Lakes
- Cities

0 25 50
Miles

August 2007

State of Arizona Multi-Hazard Mitigation Plan

Map 21
Peak Acceleration for Earthquake
as of 2007

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.